DOCUMENT RESUME

ED 462 952 IR 021 110

AUTHOR	Wetzel, David R.
TITLE	A Model for Pedagogical and Curricula Transformation with Technology.
PUB DATE	2001-06-00
NOTE	12p.; In: Building on the Future. NECC 2001: National Educational Computing Conference Proceedings (22nd, Chicago, IL, June 25-27, 2001); see IR 021 087.
AVAILABLE FROM	For full text: http://confreg.uoregon.edu/necc2001/program/.
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Case Studies; Computer Uses in Education; Curriculum Development; *Educational Technology; Faculty Development; *Instructional Development; Middle Schools; Models; Science Instruction; Science Teachers; Secondary School Science; *Teacher Attitudes; *Teaching Methods; *Technology Integration
IDENTIFIERS	Barriers to Implementation; *Technology Implementation

ABSTRACT

The purpose of this study was to investigate the factors that influenced five middle school science teachers as they implemented and integrated instructional technology in their curricula, along with determining the effects that implementation and integration of instructional technology had on their pedagogy and curricula. The study involved empirical research with both qualitative and quantitative data. Data analysis included a cross-case analysis of multiple case studies. Data were gathered August 1999 through December 1999. This time period was selected because it provided the opportunity to test the ST[cubed]AIRS (Staff development, Time, Trainers, Transition, Access, Involvement, Recognition, Support) Model in a school setting from the beginning process of implementation and integration of a new technology. Findings are presented in the framework of the following research questions: (1) What were the teachers' concerns regarding the implementation and integration of technology? (2) What changes in teaching strategies and techniques did the teachers make when implementing and integrating technology? and (3) What were the strengths and weaknesses of the ST[cubed]AIRS Model? (Contains 20 references.) (MES)

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By: David R. Wetzel

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A Model for Pedagogical and Curricula Transformation with Technology

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Key Words: staff development, contextual barriers, instructional technology, pedagogy

Introduction

The purpose of this study was to investigate the factors that influenced five middle teachers as they implemented and integrated instructional technology in their curricula. Along with determining the effects implementation and integration of instructional technology had on their pedagogy and curricula. The study involved empirical research with both qualitative and quantitative data. Data analysis included a cross-case analysis of multiple case studies. Data were gathered August 1999 through December 1999. This time period was selected because it provided the opportunity to test the ST^{3}AIRS Model in a school setting from the beginning process of implementation and integration of a new technology.

Why is it difficult to implement technology in schools?

The availability of instructional technology for teachers is increasing in middle school science to meet societal demands and goals. Society's goals include the use of instructional technology as part of everyday instruction in school to prepare children to meet the needs of an increasing technological dependent culture (ISTE, 1998). These goals include the implementation and integration of instructional technology to facilitate the teaching and learning process through curricula transformation. However, teachers have not rushed to change their classroom instructional strategies or shift their pedagogical practices to include instructional technology. This transpires in spite of increased accessibility to better hardware and software, along with an increase in staff development opportunities (U.S. Congress, Office of Technology Assessment, 1995). Teacher resistance to change is primarily due to their concerns regarding the influence of instructional technology integration on their preparation, beliefs, and values. These concerns include teacher technical ability and proficiency with instructional technology, along with organizational culture and climate influences that are beyond the control of the teachers (Dexter, Anderson, & Baker, 1999). These concerns include the influence of their school climate and culture facilitating or presenting barriers (U.S. Congress, Office of Technology Assessment, 1995; Becker, 1991).

Becker and Riel's (1999) research found that the work of integrating instructional technology strategies into practice is a complex process and that teachers encounter either a bureaucratic culture or a professional culture in their school. Bureaucratic cultures tend to give teachers autonomy in their classrooms, but restrict their participation in curricular and organizational decisions. The bureaucratic culture hinders innovative practice and collaboration among teachers. In contrast, professional cultures support innovation and collaboration among teachers. In this culture, decisions are based on a guiding philosophy about teaching and learning and sensitivity to the learning needs of students. In previous research, Becker (1991) found that only 5 % of technology implementation programs succeed beyond a three-to-five-year period in schools.

Background

While National Education Technology Standards for Teachers (ISTE, 2000) provide goals for teachers that are not all-inclusive, instructional technology has strongly influenced the education is taught in the United States. The use of technology in education has grown out of the personal experiences of teachers and students, along with the need for instructional technology to support national standards in science, math, social studies, and language arts.

Contextual Barriers to Change

A major challenge to educational innovation is assisting teachers in unlearning the beliefs, values, assumptions, and culture that underlie their school's standard operating procedures and practices (Dede, 1999). To be successful beyond initial implementation, school systems need to assist teachers in learning, but also aiding them in unlearning their standard organization's operating procedures. The goals of the innovation implementation must include organizational changes as teachers learn. A shift in organizational change will sustain change that can only be achieved when owned by teachers and not imposed or mandated (Dede, 1999).

Figure 1 illustrates common barriers to the use of instructional technology. These barriers include time, funding, rationale for use, training and support, apathy, teacher involvement, vision, access to hardware and software, and adequate assessment practices. Of those illustrated, research by the U.S. Congress, Office of Technology Assessment (1995) indicated that time is the greatest barrier to teacher's implementation and integration of instructional technology. The time barrier is supported by the many demands on a teacher during the course of a school day, with little or no time allotted to explore instructional technology, collaborate with other teachers about applications of this technology, and integration of the technology into their teaching strategies and techniques.

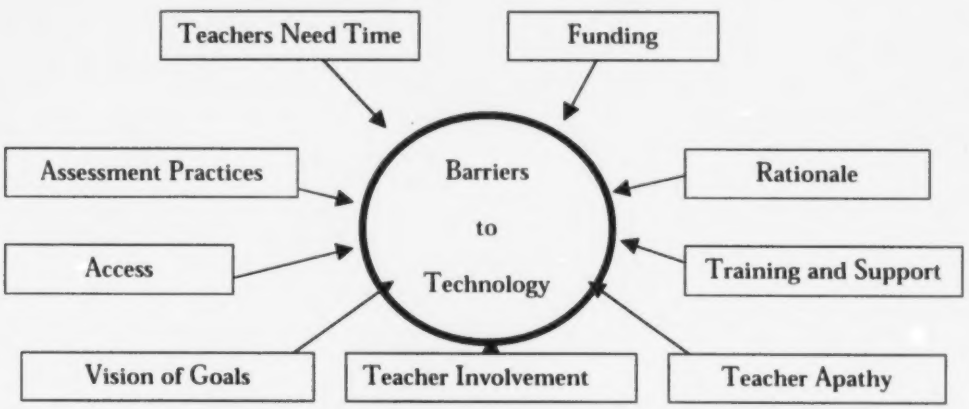

Figure 1: Common barriers to teachers using instructional technology.

Note. From the U.S. Congress, Office of Technology Assessment, 1995.

Overcoming these Contextual Barriers

The challenge of integrating instructional technology is not only providing assistance to teachers to learn how to operate a technological tool; it is helping them to learn to integrate the technology tool in their curriculum. To effectively integrate the use of this technology, several approaches will ease the concerns of teachers, increase the level of use, and provide examples of best practices for changes in teaching strategies. These approaches include training master teachers, providing expert

resource assistance, providing adequate staff development for teachers, providing staff development for administrators, and establishing technology training centers within the school districts (Ravitz, Wong, & Becker, 1999).

Although the problem of instructional technology integration has many solutions, the best appear to be in making time for staff development and providing support for teachers. Instructional technology takes time to master. Hardware and software, no matter how "user-friendly," require time to master. As in any profession, time must be invested in learning how to use an instructional technology tool before real integration in curricula can occur. Figure 2, adapted from U.S. Congress, Office of Technology Assessment (1995) illustrates the requirements for effective use of technology.

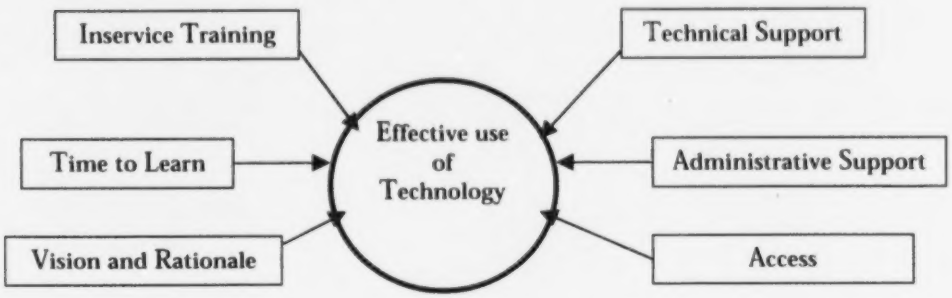

Figure 2. Requirements for effective use of instructional technology.

Note. Adapted from the U.S. Congress, Office of Technology Assessment, 1995.

Literature Review

The literature regarding implementation, integration, and transformation is broad-based with respect to instructional technology. The broad-based literature does not adequately represent the specific underlying concerns and changes teachers make in the integration and the ultimate transformation of their pedagogy. The findings of this study provide supporting research in this area with an in-depth analysis of factors that influenced five middle school science teachers.

Standards and Instructional Technology

The integration of instructional technology in schools is a fact of life in American education. Along with integration, the ability of students to use instructional technology is recognized as an essential skill by society. Recognizing the responsibility to prepare students to work and live in a technological society, national education standards recommend integration of instructional technology in teaching. These standards include the *National Education Technology Standards for Students* (ISTE, 1998), *National Education Technology Standards for Teachers* (ISTE, 2000), *National Standards for Social Studies Teachers* (NCSS, 2000), *National Science Education Standards* (NRC, 1996), and *Principles and Standards for School Mathematics* (2000). Position statements by the Nation Association for Education of Young Children (2000) and National Council of Teachers of English (2000) provide guidelines for the use of instructional technology in teaching. These standards and position statements advocate the use of instructional technology by teachers to encourage students to become active participants in the learning process.

Teachers' Beliefs and Change Regarding Instructional Technology

Although teachers have the advantage of an unprecedented amount of instructional technology for use in their classrooms and schools, little evidence indicates that teachers systematically integrate technology in their classroom curriculum. Several factors erode efforts by school districts or schools as they make an effort to sustain an effective technology program. Factors that influence their efforts include a focus on hardware rather than on implementation processes, a weak implementation planning process that fails to meet the needs of teachers, and little or no professional staff development. To be successful with technology implementation, teachers need to change their pedagogy. This teacher change is a process that requires a shift in a teacher's paradigm as he or she implements a new innovation that has an influence on their pedagogy (Dexter, Anderson, & Becker, 1999).

Change is a process that may span a period of years and the recognition of this process by those concerned during the implementation of a new instructional strategy or technological tool is important. Individual teachers can accomplish change, but only when these teachers take ownership in a new instructional strategy or technological tool will sustained change take place. This change may take two to three years for a new technology tool to be fully implemented and integrated within a curriculum.

Teacher Change

Change is a personal human experience that needs to be considered by school systems and change facilitators when implementing a new program. To successfully implement the integration of a new technological tool, consideration of what the implementation will mean to teachers' personal beliefs and values is of great concern. How will it affect their current classroom practices, preparation time, beliefs regarding technology, and values? What factors directly and indirectly influence teachers' integration of instructional technology (Dexter, Anderson, & Becker, 1999)?

Teachers' beliefs and values regarding change that are incompatible with the implementation and integration of a new instructional technology tool are a major obstacle. For these teachers to accept change in their pedagogy to adapt a new technological innovation, they must first experience conflict within their expectations. For teachers to conceptually change their teaching strategies and techniques, they need to (Posner, Strike, Hewson, & Gertzog, 1982): become dissatisfied with their existing conditions; view change as intelligible; view change as plausible; and find change useful in a variety of new situations.

Through time teachers have developed resilient teaching practices, due to ever shifting goals and policies that influence their pedagogy. To accommodate this process, teachers look for and use reliable teaching strategies effective with large groups of students in small places. They must be convinced that new strategies are efficient and effective.

To effectively understand the process of teacher change, one must adhere to the premise that a teacher becomes a learner. Teachers who want to change are teachers who want to grow and do not believe in the status quo. Teachers who are reflective are continually trying to do what is best for their students. Schubert and Ayers (1992) contended that only reflective teachers continuously grow.

In their research involving 608 teachers, Buck and Horton (1996) found that teachers believed their teaching had been transformed by the integration of instructional technology in their curricula. These teachers' perceived changes in their pedagogy resulted in more complex material and concepts for their students, that their students needs were met, and that they had shifted from teacher-centered to student-centered instruction.

Teacher Beliefs and Values

A teacher's epistemology is a product of his/her own prior knowledge, development, and experience as teacher. Each teacher's teaching style is influenced by personal factors, including his/her personality and belief system. But all teachers' styles are influenced by the context of the organizational structure in which they teach. For instructional technology to be successfully implemented, teacher beliefs and values need to shift. If not, the desired implementation and integration of instructional technology in education will not occur on a broad scale

From a Vygotskian perspective, humans develop and change as they interact with others and learn to make use of a culture's tools, both physical and psychological. So the constructions that humans make in their minds originate in interchanges with people and influence their beliefs and values. The transformation from the inter-psychological to intra-psychological takes place within a person's "zone of proximal development (ZPD)" (Vygotsky, 1978). Because the teacher is a learner when implementing and integrating an innovation, the teacher who is an expert becomes a novice. In learning new teaching strategies, a teacher's ZPD is concentrated learn new things that may conflict or support their beliefs and values. Since much of teacher change is revolutionary, teachers need time to reinforce and deter resistance to change. Martin (1993, p. 84) argued that "Without time and support for constructive interaction, there is no chance that the teacher will appropriate the new information."

Theoretical Framework

The framework for this study was the ST^{3}AIRS Model (Figure 3). Through this framework pedagogical support and technical assistance was provided during the study period.

ST^{3}AIRS Model consists of eight steps developed to overcome contextual barriers to teachers as they integrated technology. These eight steps are staff development, time to learn, trainer that was qualified, transition time to implement technology, access to hardware and software, involvement by teachers in the process, recognition of teachers, and support for teachers. The ST^{3}AIRS Model focused on strategies for the implementation and integration of the teachers involved in the study to influence changes in their pedagogy, along with curricula changes related to the implementation and integration of this technology. Research by Dexter, Anderson, and Becker (1999) found that contextual barriers influence instructional practices, teaching strategies, classroom management, technical expertise, curriculum directives, and organizational support for teachers. Support for the teachers involved in the study included staff development sessions, technical assistance, support for modifications of laboratory lessons and techniques to improve student learning, and problem solving strategies and techniques to support integration.

Methodology

The study was an empirical multiple-case design that used the dominant-less dominant qualitative-quantitative approach to eliminate misleading associations (Creswell, 1994). As part of this approach, descriptive numeric methods were used to analyze quantitative data. Cross-case analysis of the five teachers in this study, allow conclusions that are drawn from the findings in relation to the research questions and are constructed into a rich understanding of influences on these teachers from a personal perspective. Using larger numbers of teachers may replicate previous findings and add little beyond existing literature. Additionally, a larger number of teachers would limit the study's ability to conduct an in-depth analysis of influences that these

teachers encountered as they integrated instructional technology. Also, a larger group could limit the study's ability to obtain the teacher trust and confidence.

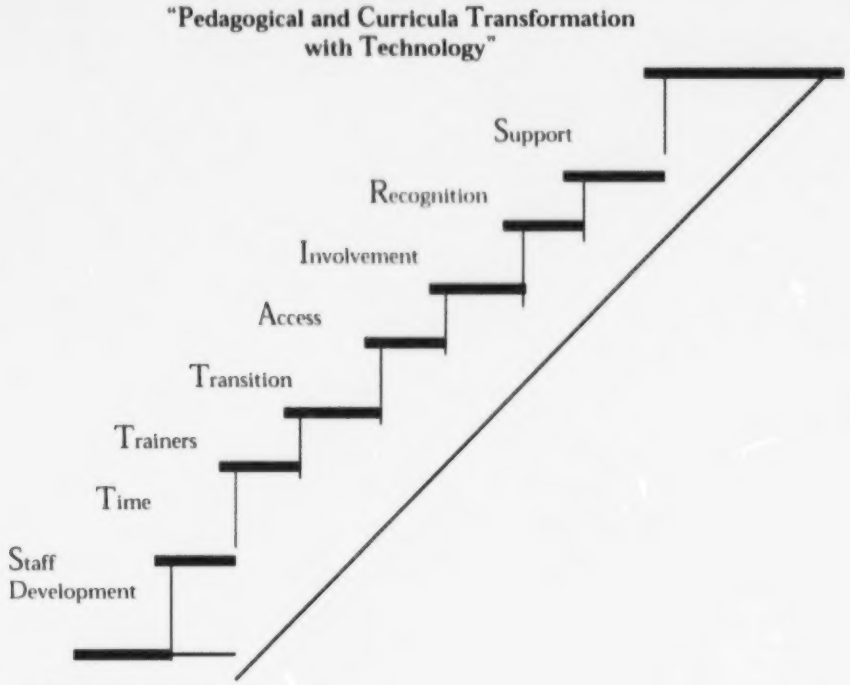

Figure 3. ST³AIRS Model.

Overview of the Site and Sample

The teachers in the study were all in a middle school located in a suburban community of Virginia. The school was in a predominately middle to low socioeconomic setting. The school system was small having four elementary schools, one middle school, and one high school. The middle school's population was approximately 750 students ranging in from grades six through eight. Ethnic make up of the school was 70% European American, 20% African American, 5% Hispanic, and 5% other minorities. Approximately 30% of students enrolled in the school were eligible for the free or reduced lunch program, and less than 10 percent of the school's student population was considered transient. All students were enrolled in science, which was one of the core content requirements for each respective grade level in the school.

Teachers

The teachers involved in the study were science teachers either full or part-time, and only one was a science major. Mathematics was the second content subject taught by the teachers who were part-time science teachers. Science content consisted of sixth-grade general science, seventh-grade life science (introductory biology), and eighth-grade physical science (introductory physics and chemistry). Five of the nine science teachers in the school participated in the study. Two were sixth-grade science and teachers, one was a seventh-grade science teacher, and two teachers were eighth-grade science teachers. Table 1 provides selected demographics of the participants.

Table 1: Selected Demographics of Study Participants

Teacher	Years[1] Teaching	Grade Level	Years in[2] Leadership	Level[3] of Technical Proficiency	Technology[4] College Credits	MS[5]	Ethnic Origin
1	11	8	0	II	8	No	European American
2	26	6	10	II	9	No	European American
3	21	8	2	I	9	Yes	European American
4	23	6	1	III	6	No	African American
5	33	7	0	I	6	Yes	European American

1. Years of teaching experience.
2. Leadership as a science department head, state organizations, or team leader.
3. Current level of Virginia Teacher Technology Competency Certification.
4. Instructional technology credits completed in higher education.
5. Master's degree.

Research Questions

The following questions provided the focus regarding implementation, integration, and curricula transformation of CBL probeware by the teachers involved in the study:

1. What were the middle school science teachers' concerns regarding implementation and integration of technology?
2. What changes in teaching strategies and techniques did these middle school science teachers make when implementing and integrating technology?
3. What were the strengths and weaknesses of the ST^{3}AIRS Model?

Data Collection

Three interviews of each teacher were conducted to collect qualitative data in relation to technology implementation and integration. These three interviews were the Initial Teacher Interview, Levels of Use Interview, and Final Teacher Interview. Quantitative data were collected using three instruments from the CBAM Model (Hall, 1974). These three instruments were used to collect data regarding the integration of technology and included the Stages of Concern Questionnaire (SoCQ) regarding the use of an innovation, the Levels of Use (LoU) of an innovation, and Innovation Configuration (IC) regarding the actual implementation and integration of an innovation (Loucks & Hall, 1979). Figure 4 provides a timeline for data collection during the study.

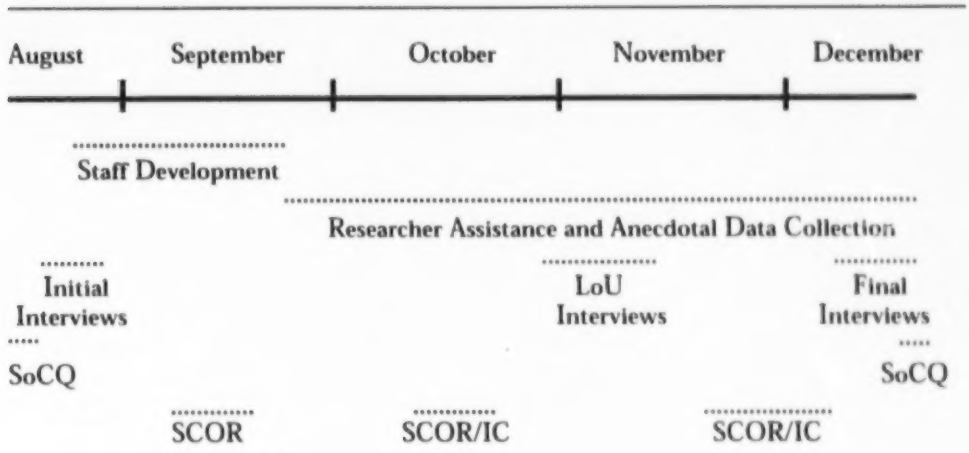

Figure 4. Data collection timeline August–December 1999.

Data Analysis

Data analysis was an ongoing process, beginning with the first interview. Initial data analysis was through the use of individual case studies of the five teachers using interviews, questionnaires, and observations. After analysis of each case study, a cross-case analysis was conducted on the case studies looking for common patterns. Triangulation of data used multiple sources of data to reduce researcher bias and provide a better assessment generality of the findings and conclusions (Creswell, 1994). These multiple sources of data included interviews, questionnaires, and observations as part of the triangulation approach. Interviews provided insight into the teachers' personal experiences during the technology implementation and integration process.

Findings

General conclusions can be drawn from the evidence of this study through case study findings and cross-case analysis of the data. The following general conclusions are presented through the framework of the research questions.

Research Question 1: What were the teachers' concerns regarding the implementation and integration of technology?

- Four of the five teachers had a meaningful decrease in their concerns in relation to their awareness and information regarding their integration of this technology.
- All five teachers were concerned with limited hardware resources that restricted the collaborative efforts of the teachers to integrate this technology in their curricula.
- Four of the five teacher's concerns with the implementation and integration of this technology were substantially reduced by giving them ownership of the process.

Research Question 2: What changes in teaching strategies and techniques did these middle school science teachers make when implementing and integrating technology?

- Four of the five teachers had a shift in their teaching strategies and techniques in relation to this technology integration, which provided evidence of short-term transformation in their pedagogical practices and curricula.

- Four of the five teachers used a student-centered approach when using this technology with their students. Which was a shift in pedagogy for three of these four teachers.
- Four of the five teachers' views and beliefs regarding their concern with the appropriate use of this instructional technology in middle school science shifted from nonsupport to support.

Research Question 3: What were the strengths and weaknesses of the ST^{3}AIRS Model ?

- Collaboration among the teachers in the study and a sense of partnership with the researcher were instrumental in the successful short-term transformation of pedagogy and curricula by four of the five teachers.
- Staff development sessions that allowed the teachers to explore the technical aspects of CBL probeware and how it fit within their curriculum, before implementation.
- Support before, during, and after classroom implementation of technology by the teachers.
- Teachers were allowed to select the time and curriculum integration point without a sense of pressure to integrate this technology before they were ready.
- Involvement of the teachers in all phases of the implementation and integration process.
- There were no weaknesses noted by participants in the study.

Limitations and Considerations

As with all studies, there are limitations in the research design. One limitation of this study was the small number of teachers, which was five teachers. Even though there were only five teachers, their number provided in-depth findings and conclusions of the data. This limitation of five teachers does not allow the findings of this research to be generalized and are confined to the conclusions within the context of this study. However, with consideration of the contributing to the body of literature regarding this research, the findings of this study can be generalized within a similar context.

While caution must be used in generalizing the experiences of these teachers to all middle school science teachers, the study indicates that within this context there was an 80 % success (i.e., four of five teachers) for short-term pedagogical and curricula transformation. This 80 % success rate exceeds the findings of research completed by Becker (1991), who found that only 36 % of teachers were willing to transform their pedagogy and curriculum to include instructional technology.

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